CLAIMS

What is claimed as new and desired to be protected by Letters Patent of the United States is:

1. A pixel cell for an image sensor, the pixel cell comprising:

a photodiode for generating charge in response to light and for amplifying the generated charge, the photodiode being over a surface of a substrate and comprising a plurality of layers, wherein at least a first layer has a first band gap and at least a second layer has a second band gap; and

a gate adjacent to the photodiode for transferring the amplified charge from the photodiode.

2. The pixel cell of claim 1, wherein a difference between the conduction band energies of the first layer and the second layer is greater than a difference between the valence band energies of the first layer and the second layer.

3. The pixel cell of claim 1, wherein a difference between the valence band energies of the first layer and the second layer is greater than a difference between the conduction band energies of the first layer and the a second layer.

4. The pixel cell of claim 1, wherein the layers are configured to promote ionization by a first carrier type and suppress ionization by a second carrier type.

5. The pixel cell of claim 1, wherein the layers are each formed of a material selected from the group consisting of Si, Si_xGe_{1-x}, $Si_xGe_{1-x}C_y$, GaAs, GaAlAs, InP, InGaAs, or InGaAsP.

6. The pixel cell of claim 1, wherein the first layer is Si and the second layer is SiGe.

7. The pixel cell of claim 6, wherein the photodiode comprises at least two layers of Si and at least two layers of SiGe, wherein the layers of Si are doped to a first conductivity type, wherein the layers of SiGe are doped to a second conductivity type, and wherein the layers of Si are alternated with the layers of SiGe to form an Si/SiGe structure.

8. The pixel cell of claim 6, wherein the photodiode comprises at least four layers of Si and at least four layers of SiGe, wherein the layers of Si are alternated with the layers of SiGe to form an Si/SiGe structure, wherein at least a first subset of layers is doped to a first conductivity type, and wherein at least a second subset of layers is doped to a second conductivity type.

9. The pixel cell of claim 1, wherein the first layer is Si_xGe_{1-x} and the second layer is Si_yGe_{1-y}.

10. The pixel cell of claim 1, wherein the first layer is $Si_xGe_{1-x}C_y$ and the second layer is $Si_xGe_yC_z$.

11. The pixel cell of claim 1, wherein at least a portion of the photodiode is at a level below the level of a top surface of the substrate.

12. The pixel cell of claim 1, wherein the photodiode comprises approximately 10 to approximately 100 layers.

13. The pixel cell of claim 1, wherein each of the layers have a thickness of approximately 50 Angstroms to approximately 300 Angstroms.

14. The pixel cell of claim 1, further comprising a graded buffer layer between a bottom layer of the photodiode and a surface of the substrate.

15. The pixel cell of claim 1, wherein the transistor is a reset transistor for resetting the photodiode to a predetermined voltage.

16. The pixel cell of claim 1, further comprising a floating diffusion region, wherein the transistor is a transfer transistor for transferring charge from the photodiode to the floating diffusion region.

17. The pixel cell of claim 1, wherein the photodiode is part of a CMOS image sensor.

18. The pixel cell of claim 1, wherein the photodiode is part of a charge coupled device image sensor.

19. The pixel cell of claim 1, wherein the substrate is a silicon-on-insulator substrate.

20. An image sensor comprising:

an array of pixel cells at a surface of a substrate, wherein at least one of the pixel cells comprises a photodiode, the photodiode comprising a plurality of layers, wherein at least a first layer comprises a first material and at least a second layer comprises a second material, wherein the layers are configured such that a difference between the conduction band energies of the first and at least second materials and a difference between the valence band energies of the first and at least second materials promotes ionization by a first carrier type and suppresses ionization by a second carrier type; and

a gate adjacent to the photodiode for transferring the amplified charge from the photodiode.

21. The image sensor of claim 20, wherein the first and at least second materials are selected from the group consisting of Si, Si_xGe_{1-x}, $Si_xGe_{1-x}C_y$, GaAs, GaAlAs, InP, InGaAs, or InGaAsP.

22. The image sensor of claim 20, wherein the first material is Si and the second material is SiGe.

23. The image sensor of claim 22, wherein the photodiode comprises at least two layers of Si and at least two layers of SiGe, wherein the layers of Si are doped to a first conductivity type, wherein the layers of SiGe are doped to a second conductivity type, and wherein the layers of Si are alternated with the layers of SiGe to form a Si/SiGe structure.

24. The image sensor of claim 22, wherein the photodiode comprises at least four layers of Si and at least four layers of SiGe, wherein the layers of Si are alternated with the layers of SiGe to form a Si/SiGe structure, wherein at least a first subset comprising two layers of Si and two layers of SiGe is doped to a first conductivity type, and wherein at least a second subset comprising two layers of Si and two layers of SiGe is doped to a second conductivity type.

25. The image sensor of claim 20, wherein the first material is Si_xGe_{1-x} and the second material is Si_yGe_{1-y}.

26. The image sensor of claim 20, wherein the first material is $Si_xGe_{1-x}C_z$ and the second material is $Si_xGe_yC_z$.

27. The image sensor of claim 20, wherein the photodiode comprises approximately 10 to approximately 100 layers.

28. The image sensor of claim 20, wherein the transistor is a reset transistor for resetting the photodiode to a predetermined voltage.

29. The image sensor of claim 20, further comprising a floating diffusion region, wherein the transistor is a transfer transistor for transferring charge from the photodiode to the floating diffusion region.

30. The image sensor of claim 20, wherein the pixel cell further comprises readout circuitry connected to a floating diffusion region for reading out charge.

31. The image sensor of claim 20, further comprising circuitry peripheral to the array, the peripheral circuitry being at a surface of the substrate, wherein the substrate is a silicon-on-insulator substrate.

32. An image sensor comprising:

an array of pixel cells, wherein at least one of the pixel cells comprises:

a photodiode, the photodiode comprising alternating layers of Si and Si_xGe_{1-x}; and

a gate adjacent to the photodiode for transferring the amplified charge from the photodiode.

33. The image sensor of claim 32, wherein x is approximately 0.5, wherein the layers of Si are doped to a first conductivity type, and wherein the layers of Si_xGe_{1-x} are doped to a second conductivity type.

34. The image sensor of claim 32, wherein x is approximately 0.5, and wherein first and at least second subsets of the layers are doped to first conductivity and second conductivity types, respectively.

35. A processor system, comprising:

a processor; and

an image sensor coupled to the processor, the image sensor comprising:

an array of pixel cells, at least one of the pixel cells comprising:

a photodiode, the photodiode comprising layers of a first material and at least a second material in contact with one another, wherein the first and second materials are selected from the group consisting of Si, Si_xGe_{1-x}, $Si_xGe_{1-x}C_y$, GaAs, GaAlAs, InP, InGaAs, or InGaAsP, wherein the layers are configured to promote ionization by a first carrier type and suppress ionization by a second carrier type;

a gate of a transistor adjacent to the photodiode;

a floating diffusion region electrically connected to the first transistor; and

readout circuitry electrically connected to the floating diffusion region.

36. The system of claim 35, wherein a difference between the conduction band energies of the first and second materials is greater than a difference between the valence band energies of the first and second materials.

37. The system sensor of claim 35, wherein a difference between the valence band energies of the first and second materials is greater than a difference between the conduction band energies of the first and at least second materials.

38. A method of forming a pixel cell for an image sensor, the method comprising:

forming a photodiode, the act of forming the photodiode comprising forming a plurality of layers over a surface of a substrate, the act of forming the plurality of layers comprising forming at least a first layer of a first material and at least a second layer of a second material, wherein the first material layer has a first band gap and the at least second material has at least a second band gap; and

forming a gate of a transistor adjacent to the photodiode.

39. The method of claim 38, wherein the act of forming alternating layers comprises forming the layers such that a difference between the conduction band energies of the first and at least second materials is greater than a difference between the valence band energies of the first and at least second materials.

40. The method of claim 38, wherein the act of forming alternating layers comprises forming the layers such that a difference between the valence band energies of the first and at least second materials is greater than a difference between the conduction band energies of the first and at least second materials.

41. The method of claim 38, wherein the act of forming the layers comprises forming the layers of materials selected from the group consisting of Si, Si_xGe_{1-x}, $Si_xGe_{1-x}C_y$, GaAs, GaAlAs, InP, InGaAs, or InGaAsP.

42. The method of claim 38, wherein the act of forming the layers comprises forming alternating layers of Si and SiGe.

43. The method of claim 42, wherein the act of forming the layers comprises doping the layers of Si to a first conductivity type and doping the layers of SiGe to a second conductivity type.

44. The method of claim 42, wherein act of forming the layers comprises doping a first subset of layers to a first conductivity type and doping at least a second subset of layers to a second conductivity type.

45. The method of claim 38, further comprising forming a floating diffusion region adjacent to the gate and forming readout circuitry electrically connected to the floating diffusion region for reading out charge.

46. The method of claim 38, wherein the layers are formed by any of chemical vapor deposition, atomic layer deposition, epitaxy and ion implantation.

47. The method of claim 38, wherein the act of forming the photodiode comprises forming at least a portion of the photodiode at a level below a level of a top surface of the substrate.

48. The method of claim 38, wherein the act of forming the layers comprises forming approximately 10 to approximately 100 layers.

49. The method of claim 38, wherein the act of forming the layers comprises forming the layers having a thickness of approximately 50 Angstroms to approximately 300 Angstroms.

50. The method of claim 38, further comprising forming a graded buffer layer between a bottom layer of the photodiode and a surface of the substrate.

51. The method of claim 38, wherein the act of forming the photodiode comprises forming the plurality of layers over a surface of a silicon-on-insulator substrate.

52. A method of amplifying photo-generated charge in an image sensor comprising an array of pixel cells, the method comprising:

generating charge carriers of first and second types in response to light in a plurality of photodiodes of respective pixel cells;

amplifying the generated charge carriers by applying an electric field to the plurality of photodiodes to move the generated carriers from a layer of a first material to at least a layer of a second material causing the generated carriers to ionize; and

promoting ionization of a first carrier type and suppressing ionization of a second carrier type.

53. The method of claim 52, wherein the first carrier type is electrons, and wherein the acts of promoting and suppressing comprise providing the first and second materials such that a difference between the conduction band energies of the first and second materials is greater than a difference between the valence band energies of the first and second materials.

54. The method of claim 52, wherein the first carrier type is holes, and wherein the acts of promoting and suppressing comprise providing the first and second materials such that a difference between the valence band energies of the first and second materials is greater than a difference between the conduction band energies of the first and second materials.